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Single Grains and Grain Mixtures as Supplements to Alfalfa Hay and Silage for Milk Production¹

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INTRODUCTION

For many years dairymen and dairy investigators have recommended that the grain ration for dairy cows be made up of several kinds of grain or grain byproducts, including high-protein concentrates. This recommendation is based largely on the belief that the grain ration will be more palatable and that no essential nutrient (especially amino acids of the proteins) is likely to be lacking if the ration contains a number of different grains and grain byproducts.

Purchased grains, especially high-protein concentrates and grain byproducts, normally are more expensive to feed than home-grown grains. More dependence on simple rations of home-grown feeds would save the extra cost and the inconvenience sometimes encountered by dairy farmers in preparing complicated grain rations from purchased materials. Commercial feedstuffs are sometimes scarce and difficult to obtain, which is the situation in the present wartime emergency. Consequently it is important that dairy farmers recognize the possibilities of obtaining economical and abundant milk production by using simple rations made up of grains grown on the farm.

Feeding trials at the Wisconsin Experiment Station,³ comparing a simple grain ration of corn and oats with a mixture of corn, oats,

¹ Submitted for publication December 1943.

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³ RUSSELL, H. L., and MORRISON, F. B. NEW PAGES IN FARMING: ANNUAL REPORT OF THE DIRECTOR 1920-1921. Wis. Agr. Expt. Sta. Bul. 339, pp. 129-130, illus. 1922.

RUSSELL, H. L., and MORRISON, F. B. SCIENCE SERVES WISCONSIN FARMS. (ANNUAL REPORT OF THE DIRECTOR, 1921-1922.) Wis. Agr. Expt. Sta. Bul. 352, 22 pp., illus. 1923.

linseed meal, and cottonseed meal, showed that when the cows received plenty of choice alfalfa hay there was no need to purchase expensive protein-rich concentrates to keep up good production.

At the Ohio Experiment Station⁴ two Holstein cows produced well on alfalfa hay and a grain ration consisting of corn only. One cow was started on this ration when she had been in milk 5 months. Eight months later she dropped a 105-pound calf and during the next 5 months she averaged 1,264 pounds of milk per month. In 13 months on this ration she produced 11,040 pounds of milk and 382 pounds of butterfat. The other cow produced, in 12 months, 11,276 pounds of milk and 351 pounds of butterfat.

Very few experiments have been reported in which a single-grain ration has been fed over a long period (full lactation), but most experiments in which home-grown grain rations have been fed have indicated the necessity of feeding plenty of good legume hay in order to supply enough protein.

The purpose of this publication is to present the results of experiments by the Bureau of Dairy Industry, in which cows were fed a single-grain ration—such as barley, corn, or kafir—in comparison with grain rations made up of four to six different grains, grain byproducts, and high-protein concentrates.

EXPERIMENTAL PROCEDURE

The Bureau of Dairy Industry has conducted numerous experiments that have shown the economy and the necessity of providing high-quality roughages to dairy cattle and for many years it has advocated that practice. When this experiment was started in 1941 to compare single-grain rations with grain mixtures, it was decided as a matter of course that the basal roughage ration should consist of liberal quantities of high-quality legume hay and silage. The experiment was carried out separately at each of three field experiment stations—Mandan, N. Dak., Hannibal, Mo., and Woodward, Okla. The single grain fed in each case was one commonly grown in the locality of the particular field station.

Two groups of 4 cows each were placed on the experimental rations at each station, making a total of 24 cows at the 3 stations. The cows were selected so as to balance the groups as nearly as possible. Table 1 gives the age and weight of the animals at the start of the experiment, also their first-calf production records as 2-year-olds.

Registered Holsteins were used at the Mandan and Woodward stations and registered Jerseys at the Hannibal station. All cows were started on the experimental rations at calving time and, since they all calved at about the same time at the respective stations, the effect of seasonal conditions was not a factor in their relative production. The cows were fed the experimental rations for 365 days unless they went dry before that time.

The cows were weighed at the beginning and at the end of the experiment and also monthly throughout the lactation period. The milk was weighed daily and it was tested for butterfat content one day in

⁴ MONROE, C. F., and HAYDEN, C. C. POSSIBILITY OF A HOME-GROWN DAIRY RATION. Ohio Bi-Mo. Bul. 158, pp. 172-178. 1932.

TABLE 1.—*First-calf production records (as 2-year-olds) of the cows selected for each experimental group, and their age and weight at the start of the experiment*

MANDAN, N. DAK., STATION

Single-grain groups					Mixed-grain groups				
Cow No.	Age at start of experiment	Weight at start of experiment	Actual production as a 2-year-old		Cow No.	Age at start of experiment	Weight at start of experiment	Actual production as a 2-year-old	
			Milk	Butter-fat				Milk	Butter-fat
	<i>Yr. Mo.</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>		<i>Yr. Mo.</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>
508.....	5 0	1,278	16,896	593	523.....	4 3	1,330	15,640	490
96.....	5 3	1,278	13,099	459	511.....	4 7	1,296	15,864	518
89.....	5 11	1,253	10,759	446	501.....	5 3	1,350	9,791	372
86.....	6 2	1,420	15,345	554	92.....	5 6	1,372	14,969	552
Average.....	5 7	1,307	14,025	513	.....	4 11	1,337	14,066	483

HANNIBAL, MO., STATION

84.....	3 7	1,033	7,429	400	62.....	6 3	1,180	6,813	414
83.....	3 7	840	6,477	399	65.....	5 9	1,050	6,906	425
78.....	4 2	1,165	8,890	487	61.....	5 9	1,085	7,574	445
75.....	4 7	920	7,139	390	90.....	3 4	930	7,693	424
Average.....	3 8	990	7,484	419	.....	5 3	1,061	7,242	427

WOODWARD, OKLA., STATION

245.....	6 0	1,295	15,778	583	268.....	3 4	1,497	11,849	513
266.....	3 3	1,145	14,146	488	223.....	7 6	1,400	13,578	470
247.....	5 3	1,281	13,521	555	235.....	6 4	1,422	14,392	520
263.....	4 0	1,260	17,049	631	265.....	3 3	1,180	15,107	532
Average.....	4 8	1,245	15,124	564	.....	5 1	1,375	13,732	508
Average for 12 cows.....	4 9	1,181	12,232	499	.....	5 1	1,258	11,681	473

¹ Record made at 3 years 9 months of age.

each month. The nutrient content of all feeds was estimated from the composition tables given by Morrison ⁵ and the nutrient requirements of the cows, both for maintenance and for milk production, were calculated according to Morrison's feeding standard for good cows under usual conditions.

Alfalfa hay and silage were fed at will and none of the cows had pasturage. Both groups at each station were fed a limited-grain ration—approximately 1 pound of grain or grain mixture for each 6 pounds of milk produced. All cows had access to bonemeal.

AT THE MANDAN STATION

At the Mandan station the single-grain ration was ground barley and the mixed-grain ration (containing 13.9 percent of digestible crude protein) consisted of equal parts of barley, flint corn, oats, wheat bran, and linseed meal. The roughage was alfalfa hay and flint-corn silage, both of good quality.

The cows were housed in a pen barn and had access to an outside

⁵ MORRISON, F. B. FEEDS AND FEEDING, A HANDBOOK FOR THE STUDENT AND STOCKMAN. Ed. 20, unabridged, 1050 pp., illus. 1936. Ithaca, N. Y.

dry lot during favorable weather; and all were milked three times a day for the entire lactation period.

The cows in the single-grain group were more mature than those in the other group but their average weight at the start of the experiment was slightly less. As 2-year-olds they had averaged slightly less milk but 6 percent more butterfat than the mixed-grain group. (See table 1.)

AT THE HANNIBAL STATION

At the Hannibal station the single-grain ration was ground yellow corn and the mixed-grain ration consisted of 1,200 pounds of ground corn, 900 pounds of crushed oats, 600 pounds of wheat bran, 300 pounds of linseed meal, 100 pounds of cottonseed meal, and 200 pounds of soybean meal. The mixed-grain ration contained 13.6 percent of digestible crude protein and 75.9 percent of total digestible nutrients. The roughage was alfalfa hay of good quality and alfalfa-molasses silage.

The cows were housed in a loafing barn and had free access to an outside dry lot, but they were tied when fed grain. All cows were milked by hand three times a day until January 1, 1943, when it became necessary to change to twice-a-day milking. Cow 62 was milked twice a day for her entire lactation of 309 days, but on the average the cows in the single-grain group were milked twice a day for 185 days and those in the other group 217 days. No correction in the production data was made for the difference in the number of daily milkings.

The cows in the single-grain group were considerably younger on the average and weighed less at the start of the experiment than those in the other group. As 2-year-olds, they had averaged 3 percent higher in milk production and 2 percent lower in butterfat production than the mixed-grain group. (See table 1.)

AT THE WOODWARD STATION

At the Woodward station the single-grain ration was ground kafir. Kafir is produced locally and used in place of corn, for which it is commonly considered a satisfactory substitute. Before the experiment was completed it was necessary to substitute ground barley for kafir, for three cows in the single-grain group. The substitution was made so late in the lactation period, however, that it probably did not affect the results. The mixed-grain ration consisted of 300 pounds of kafir, 200 pounds of wheat bran, 50 pounds of cottonseed meal, and 50 pounds of soybean meal. This ration contained 14.9 percent of digestible crude protein and 76.4 percent of total digestible nutrients. Because of a scarcity of kafir and bran, it was later necessary to change to a mixture consisting of 400 pounds of ground barley, 200 pounds of ground oats, 300 pounds of ground wheat, and 200 pounds of cottonseed meal (later replaced by soybean meal). This mixture contained 14.8 percent of digestible crude protein and 78.5 percent of total digestible nutrients. Alfalfa hay of good quality was fed throughout the experiment and the silage was made from cane.

The cows were housed in a stanchion barn and were allowed to run in a dry lot on favorable days. All cows were milked by hand three times a day for most of the experiment, but because of labor

difficulties it was necessary to change to twice-a-day milking in November 1942. This change occurred so late in the experiment, however, that it probably did not affect production. Cow 268 in the mixed-grain group was milked twice a day for the last 134 days of her lactation; the other cows were milked twice a day for short periods up to 40 days.

The cows in the single-grain group were younger and weighed less at the start of the experiment than those in the other group. As 2-year-olds they had averaged 5 percent higher in milk and butterfat production than the mixed-grain group. (See table 1.)

EXPERIMENTAL RESULTS

Table 2 shows the quantities of grain and roughage consumed by each of the 24 cows in the experiment; and also the milk and butterfat production of each cow, both on an actual basis and converted to a mature-age basis.

RESULTS AT MANDAN

The cows on the single-grain ration averaged 494 pounds of butterfat (mature-equivalent basis), which was 87 percent as much as the average of the cows on the mixed-grain ration.

Cow 96 on the single-grain ration made the highest butterfat yield in either group, even though she went dry in 324 days and was pregnant longer than any other cow. In fact, the two highest producing cows on the single-grain ration averaged more than the two highest producers on the mixed-grain ration. The average yield of the two lowest producers on the single-grain ration, however, was much lower than that of the two lowest producers on the mixed-grain ration. Perhaps some factor other than the ration influenced the production of the two low cows on the single-grain ration, but no abnormal condition was observed.

The consumption of roughage was approximately the same for both groups, but the mixed-grain group was fed 418 pounds more grain per cow because of the higher average milk yield.

RESULTS AT HANNIBAL

The cows on the single-grain ration averaged 469 pounds of butterfat (mature-equivalent basis), which was 94 percent as much as the average of the cows on the mixed-grain ration. The cows on the single-grain ration were pregnant an average of 103 days longer, however.

Production was not consistently good on either ration. Cow 62 on the mixed-grain ration, and cows 83 and 78 on the single-grain ration, produced less than was to be expected as judged by their first-calf records. Cow 62 became a nonbreeder during the experiment, which may have influenced her production. The highest production in the two groups was made by cow 84 on the single-grain ration, but the two highest records on this ration averaged lower than the two highest records on the mixed-grain ration.

The cows on the mixed-grain ration had poorer breeding records during the experiment than the other group, but this was probably not a result of the ration fed.

TABLE 2.—*Milk and butterfat production, and feed consumption of cows on single-grain rations and mixed-grain rations at the 3 field experiment stations*

MANDAN, N. DAK., STATION

SINGLE-GRAIN GROUPS										MIXED-GRAIN GROUPS									
Cow No.	Production					Feed consumption			Cow No.	Production					Feed consumption				
	Actual		Calculated		Days carried calf	Grain	Hay	Silage		Actual		Calculated		Days carried calf	Grain	Hay	Silage		
	Milk	Butter-fat	Milk	Butter-fat															
508	Pounds	16,239	538	16,920	Pounds	560	0	Pounds	523	13,285	524	16,508	204	Pounds	2,739	10,005	10,225		
86 1		16,166	616	16,651		635	210		511	18,214	575	19,307	114		3,184	10,285	9,925		
89		9,544	345	9,690		349	202		501	14,050	520	14,471	153		2,547	9,009	11,450		
86		10,625	433	10,625		433	126		92	15,444	539	15,753	203		2,734	8,776	11,445		
Average		13,156	483	13,472		494	135			15,748	540	16,510	169		2,801	9,519	10,761		

HANNIBAL, MO., STATION

Cow No.	Production				Days carried calf	Feed consumption		Cow No.	Production				Days carried calf	Feed consumption		
	Milk	Butter-fat	Milk	Butter-fat		Grain	Hay		Milk	Butter-fat	Milk	Butter-fat		Grain	Hay	
	Pounds	Pounds	Pounds	Pounds	Number	Pounds	Pounds		Pounds	Pounds	Pounds	Number	Pounds	Pounds	Pounds	
84	9,487	516	11,005	583	197	1,638	9,133	6,538	62 ²	6,074	349	6,074	0	1,048	8,177	3,830
83	5,676	258	6,584	405	100	953	9,142	6,586	65	8,080	546	8,863	205	1,503	9,802	5,770
78 ³	7,150	412	7,937	445	220	1,199	9,651	6,834	61	3,705	557	9,899	205	1,645	9,421	6,718
75 ⁴	7,592	423	8,199	444	250	1,301	8,987	6,754	90 ⁵	8,179	460	9,733	237	1,367	8,587	6,024
Average	7,476	427	8,431	469	214	1,273	9,228	6,178	-----	8,162	478	8,642	111	1,391	8,997	5,586

WOODWARD, OKLA., STATION

245	12,730	419	12,730	419	207	2,174	7,259	16,610	268	13,118	515	15,348	603	190	2,245	7,816	16,510
	14,262	499	16,829	589	79	2,404	6,983	14,778	223	14,724	495	14,724	495	132	2,475	9,134	18,100
	12,748	500	13,130	515	182	2,182	7,688	14,835	235	10,518	371	10,548	371	197	1,809	7,670	14,612
	16,236	625	17,860	688	228	2,706	7,416	16,836	265	15,071	542	17,784	640	42	2,520	7,387	16,456
Average	13,994	511	15,138	553	174	2,367	7,337	15,705		13,365	481	14,601	527	140	2,262	8,002	16,420
Average for 12 cows	11,542	474	12,347	505	174	2,001	8,752	10,836		12,425	499	13,251	531	140	2,151	8,839	10,922

¹ Milked 324 days.² Milked 309 days.³ Milked 357 days.⁴ Milked 327 days.⁶ Milked 341 days.

RESULTS AT WOODWARD

The cows on the single-grain ration averaged 553 pounds of butterfat (mature-equivalent basis), which was 5 percent more than the average of the cows on the mixed-grain ration.

As judged by their first-calf records, two cows on each ration produced below expectations and two produced somewhat more than was to be expected. The two low cows on the mixed-grain ration averaged 433 pounds of butterfat and were pregnant an average of 165 days; the two low cows on the single-grain ration averaged 467 pounds and were pregnant an average of 195 days. The two high cows on the mixed-grain ration averaged 622 pounds of butterfat and were pregnant an average of 116 days; the two high cows on the single-grain ration averaged 639 pounds and were pregnant an average of 153 days.

These differences between the two low cows on the mixed-grain ration and the two low cows on the single-grain ration, and also between the two high cows in each case, indicate that there were factors of health and environment that had a greater influence in either inducing or depressing production from that normally expected than the experimental rations themselves. These differences also appear to indicate that the single-grain ration was as efficient for butterfat production as the mixed-grain ration, under existing conditions.

RESULTS AT THE THREE STATIONS COMBINED

Considering the 3 experiments together, the 12 cows on the single-grain ration averaged 505 pounds of butterfat (mature-equivalent basis), which was 95 percent as much as the average of the 12 cows on the mixed-grain ration. (See table 2.) The cows on the single-grain ration were pregnant 34 days longer on the average, however, and they gained an average of 28 pounds more in body weight during the experiment.

The results were not entirely consistent at any of the stations, as has been stated. This is further emphasized by a comparison of the average yield of the six low cows on the single-grain ration with the average of the six low cows on the mixed-grain ration, and a similar comparison of the six high cows on each ration (mature-equivalent basis).

The six low cows on the single-grain ration averaged 416 pounds of butterfat and the six low cows on the mixed-grain ration averaged 472 pounds. The six high cows on the single-grain ration averaged 595 pounds of butterfat and the six high cows on the mixed-grain ration averaged 589 pounds. Although it was expected that the single-grain ration would have a greater depressing influence on the high-producing cows than on the low-producing cows, the reverse was the case. The six high cows on the single-grain ration averaged slightly higher than the six high cows on the mixed-grain ration, whereas the six low cows on the single-grain ration averaged considerably lower than the six low cows on the mixed-grain ration.

The low-producing cows on both rations produced less than was to be expected, as judged by their first-calf records, whereas the high-producing cows produced more than was to be expected. Some factor or factors, other than the rations, influenced the production

TABLE 3.—Average amounts of nutrients required by the 4 cows on each ration, and the amounts they obtained from the various feeds, at each of the field experiment stations

Station and ration	Days in lactation	Digestible crude protein				Total digestible nutrients				Nutrients consumed in excess of requirements	
		Required for—		Consumed in—		Required for—		Consumed in—		Digestible crude protein	Total digestible nutrients
		Main-tenance	Production	Total	Hay	Silage	Grain	Total	Hay		
Mandan:	Number	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Percent	Percent
Single-grain	355	308.3	909.6	1,217.9	1,027.4	138.2	219.8	1,385.3	1,860	56	12
Mixed-grain	365	318.9	715.0	1,033.9	1,099.0	139.9	389.3	1,538.2	2,123	49	4
Hannibal:											
Single-grain	354	264.1	449.5	688.7	978.2	315.1	79.4	1,372.5	1,792	99	23
Mixed-grain	345	234.7	450.2	685.0	953.7	284.8	174.9	1,413.3	1,620	106	17
Woodward:											
Single-grain	365	296.9	651.0	947.9	778.2	173.4	215.4	1,167.0	2,807	23	6
Mixed-grain	365	320.7	621.5	942.1	848.2	180.6	334.8	1,363.6	2,923	45	9

of some of the low-producing cows in each group, at each station, but these factors were not observed or identified by the men in charge of the experimental animals. No doubt such unidentifiable factors often influence the results of feeding experiments with livestock.

NUTRIENTS REQUIRED AND CONSUMED

The object of this experiment was to compare the efficiency for milk production of a single-grain ration and a mixed-grain ration consisting of several grains and grain byproducts, when these grain rations were used as supplements to a basal ration of high-quality roughage. The cows therefore were allowed to have all the alfalfa hay and silage they would eat and the rate of grain feeding was restricted to 1 pound for each 5.5 or 6 pounds of milk produced.

Table 3 shows the average amount of digestible crude protein and total digestible nutrients required by each group of cows at each station, according to calculations, also the amounts of protein and total nutrients in the feeds consumed.

The results, as shown in the table, indicate that the cows consumed such large amounts of hay and silage that they were able to obtain the greater part of their required nutrients from the roughage part of the ration, and that they had to obtain only a small amount of additional nutrients from the grain ration in order to meet their total requirements.

Table 4 shows the percentage of the protein and total nutrient requirement of each group of cows that was obtainable from the hay and silage they consumed.

TABLE 4.—*The percentage of the required nutrients that was available in the hay and silage consumed by each group of cows*

Station	Digestible crude protein		Total digestible nutrients	
	Single-grain group	Mixed-grain group	Single-grain group	Mixed-grain group
	Percent	Percent	Percent	Percent
Mandan, N. Dak.....	128	111	87	80
Hannibal, Mo.....	188	181	108	98
Woodward, Okla.....	100	109	82	86
Average.....	139	134	92	88

The hay and silage on the average furnished more digestible crude protein than was required, the excess being more than one-third of the amount required. These roughages also furnished 92 percent of the total nutrients required by the single-grain group and 88 percent of the total nutrients required by the mixed-grain group. From these figures it will be apparent that neither group of cows needed any grain to meet their requirements for digestible crude protein; and that the cows on the single-grain ration needed only enough grain to furnish 8 percent of their total nutrient requirements, and the mixed-grain group needed only enough to furnish 12 percent of their nutrient requirements.

It is not known, of course, whether the production level would have been as high if the amount of grain had been restricted to the amount

needed to furnish 8 or 12 percent of the total nutrients required. Also, it is doubtful whether this experiment indicates what the relative values of single-grain rations and mixed-grain rations would be for milk production, if the roughage rations were restricted to the point where a larger percentage of the total nutrients would have to be obtained from the grain in the ration. It does show that when cows have the opportunity to consume as much good legume hay and silage as they will eat, it makes very little difference whether the additional required nutrients are obtained from a single grain or a mixture of several grains.

FEED COST PER POUND OF BUTTERFAT

Table 5 shows the cost of the feed consumed by the two groups of cows at each station, based on the current market prices for the feeds used; also the feed cost per pound of butterfat produced by the cows on each ration.

TABLE 5.—*Feed costs per ton and per pound of butterfat produced on the 2 rations*

Station	Single-grain ration	Mixed-grain ration	Alfalfa hay	Silage	Cost of feed per pound of butterfat	
					Single-grain ration	Mixed-grain ration
	<i>Dollars</i>	<i>Dollars</i>	<i>Dollars</i>	<i>Dollars</i>	<i>Cents</i>	<i>Cents</i>
Mandan, N. Dak.	25.00	33.40	10.00	5.00	21.7	22.4
Hannibal, Mo.	32.20	34.20	13.50	5.70	23.5	21.0
Woodward, Okla.	33.50	40.40	15.00	5.00	26.2	30.5

At these prices, there was very little difference in the cost of the feed required to produce a pound of butterfat, the average cost at the three stations being 23.8 cents a pound for the single-grain ration and 24.6 cents for the mixed-grain ration. Where farm grains can be grown at less cost than the prices of the single grains used in this experiment, the cost of producing butterfat would be correspondingly less, provided of course the cost of the mixed-grain ration was no lower.

SUMMARY AND CONCLUSIONS

At each of three field experiment stations, two groups of four cows each were fed unlimited quantities of alfalfa hay and silage throughout their lactation periods of 365 days. In addition to this basic ration of roughage, one group of cows was fed a single grain—ground barley, ground corn, or ground kafir—at the rate of approximately 1 pound to each 6 pounds of milk they produced. The other group was fed a grain mixture, at approximately the same rate, which consisted of four to six different grains, grain byproducts, and high-protein concentrates.

The cows receiving the single-grain ration had somewhat better breeding records during the experiment, gained more weight, and produced 95 percent as much butterfat as the cows on the mixed-grain rations. However, the results were not consistent and the difference in production therefore is probably not significant.

When the average yields of the six highest-producing cows on one ration are compared with those of the six highest-producing cows on the other ration, the difference in yield is negligible; but when the comparison is between the six lowest-producing cows, those receiving the mixed-grain rations average higher than those receiving the single-grain rations. This suggests that some factor other than the kind of grain ration influenced the yield of the low-producing cows in each group.

When the results of the experiment were analyzed from the standpoint of the protein and total digestible nutrients required by the cows for maintenance and milk yield, and the amounts of these constituents that were available in the hay and silage that was consumed, it was seen that only a very small proportion of the required nutrients had to come from the grain that was consumed. Such being the case, this experiment does not indicate the relative value of a single-grain ration and a mixed-grain ration when the roughages are so restricted that a large proportion of the nutrients must be furnished by the grain part of the ration.

This experiment does show that where cows have an opportunity to consume as much good hay and silage as they like, it makes little difference whether the additional nutrients they require are obtained from a single grain or a mixture of several grains and grain byproducts.

At current market prices for feeds included in the experimental rations, the cost of the feed required to produce a pound of butterfat averaged slightly less for the single-grain rations than for the mixed-grain rations.

